

**ASIAEX Scientific Analysis
-and-
ASIAEX Project Management**

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LONG-TERM GOAL

The long-term goal is to enhance our understanding of coastal oceanography by means of applying simple dynamical theories to high-quality observations obtained in the field. My primary area of expertise is physical oceanography, but I also enjoy collaborating with biological, chemical, acoustical, and optical oceanographers to work on interdisciplinary problems. I collaborate frequently with numerical modelers to improve their predictive capabilities of Navy-relevant parameters in the littoral zone.

OBJECTIVES

The objective of these two closely-related grants is to plan, execute, and analyze the data from a multi-national oceanographic field program in the East and South China Seas to investigate how the complex littoral environment (i.e., its water column, boundary, sediment and sub-bottom structure and inhomogeneities) affects the ray paths, mode structure, propagation loss, and temporal and spatial (both vertical and horizontal) coherence for low-to-intermediate frequency (50-4000 Hz) acoustic transmissions in shallow water

APPROACH

The objectives were addressed via an intensive field program in the East and South China Seas called the Asian Seas International Acoustics Experiment (ASIAEX). The ASIAEX main field program consisted of two distinct experiments; a reverberation experiment in the East China Sea (ECS) with mainland China and Korea, and a volume interaction experiment in the South China Sea (SCS) with Taiwan and Singapore. The goal of the reverberation experiment was to Develop models that can predict the mean reverberation level and fluctuations using measured environmental parameters. The

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goal of the volume interaction experiment was to understand acoustic propagation through shallow water when strong oceanic variability is present.

Professors Ramp and Chiu both served two roles for ASIAEX, as principal investigators and project managers. As the International Science Coordinator and Associate Coordinator, they handled the logistics, political matters, research vessel clearances, and planning workshops for the entire program. They also participated in the East China Sea pilot study aboard the R/V ROGER REVELLE during spring 2000 and the South China Sea volume interaction experiment aboard the Taiwanese research vessel OCEAN RESEARCHER 1 during April 2001. Professor Ramp was one of the lead physical oceanographers for the U.S. team and Prof. Chiu one of the lead acousticians. Other key individuals involved in the SCS portion of the program (our most immediate collaborators) include James Lynch, Tim Duda, and Glen Gawarkiewicz of WHOI; Marshall Orr and Steve Wolf from NRL; and David Tang and Joe Wang from NTU.

WORK COMPLETED

Field Work: The ECS pilot study was successfully completed from the R/V REVELLE during April 2000. The SCS pilot study was also completed during spring 2000 from the OCEAN RESEARCHER. The ASIAEX main field programs in the South and East China Sea were completed during spring and summer 2001. The resulting data set, collected over 108 days on eleven cruises aboard six research vessels in two marginal seas, is the largest and most comprehensive of its kind ever collected, and will serve to advance the state of the art in understanding acoustic propagation in shallow water. Some results from the SCS spring 2001 cruises conducted from Taiwanese research vessels are highlighted here. For additional information on the ECS 2001 program, see the annual report by Peter Dahl (APL/UW). For more information on the SCS SEASOAR cruises and acoustics work, see the annual reports by Gawarkiewicz (WHOI), Chiu (NPS), Lynch (WHOI) and Orr (NRL). The Low-Cost (LOCO) moorings are discussed in the annual report by Duda (WHOI).

Planning: Two ASIAEX symposia took place during FY03. The first was the ASIAEX International Symposium in Chendu, PRC, during October 2002 and the second was the ASIAEX Analysis Workshop in Taipei and Taroko Gorge, Taiwan during March 2003. Profs. Ramp and Chiu both put considerable time and effort into planning and executing these symposia. The results of both symposia have been published on CD [Tang et al., 2003; Chen et al., 2003]. The analysis workshop fostered many international collaborations for the ASIAEX special issue to appear in the IEEE Journal of Ocean Engineering.

Analysis: FY03 was a huge publication year for this project. Prof. Ramp is first author on three manuscripts and a co-author on five additional manuscripts submitted for publication (see publications list). He will also be a co-author on both the ASIAEX overview papers for the ECS and SCS. More advanced analysis including numerical simulations with postdoc H.-R. Kim are in progress. Prof. Ramp also gave oral presentations at the Chengdu symposium; the Taipei workshop; the ASIAEX special sessions at the ASA meeting in Cancun, Mexico; a NAVO transitions meeting at Stennis Space Center, MS; and the ONR solitons workshop in Williamsburg, VA.

RESULTS

New results are conveyed here that were not included in previous annual reports (see FY00, FY01, and FY02 CDs). The dominant oceanographic signal by far was in fact the highly nonlinear internal waves (or solitons) which were generated near the Batan Islands in the Luzon Strait and propagated 485 km across deep water to the observation region. Dubbed trans-basin waves, to distinguish them from other, smaller waves generated locally near the shelf break, these waves had amplitudes ranging from 29 to greater than 140 m and were among the largest such waves ever observed in the world's oceans.

The waves arrived at the most offshore mooring in two groups lasting 7 – 8 days each separated by five days when no waves were observed. Within each group, two types of waves arrived which have been named type-a and type-b (Figure 1). The type-a waves had greater amplitude than the type-b waves and arrived with remarkable regularity at the same time each day, 24 hours apart. The type-b waves were weaker than the type-a waves, arrived an hour later each day, and generally consisted of a single soliton growing out of the center of the wave packet. Comparison with modeled barotropic tides from the generation region revealed that: 1) The two groups were generated around the time of the spring tides in the Luzon strait; and 2) The type-a waves were generated on the strong side of the diurnal inequality while the type-b waves were generated on the weaker beat. The position of the Kuroshio intrusion into the Luzon Strait may modulate the strength of the waves being produced.

As the waves shoaled, the huge lead solitons first split into two solitons then merged together into a broad region of thermocline depression at depths less than 120 m. Elevation waves sprang up behind them as they continued to propagate onshore (Figure 2). The elevation waves also grew out of regions where the local internal tide forced the main thermocline down near the bottom. The “critical point” α where the upper and lower layers were equal was a good indicator of when the depression or elevation waves would form, however this was not a static point, but rather varied in both space and time according to the presence or absence the internal tides and the incoming trans-basin waves themselves.

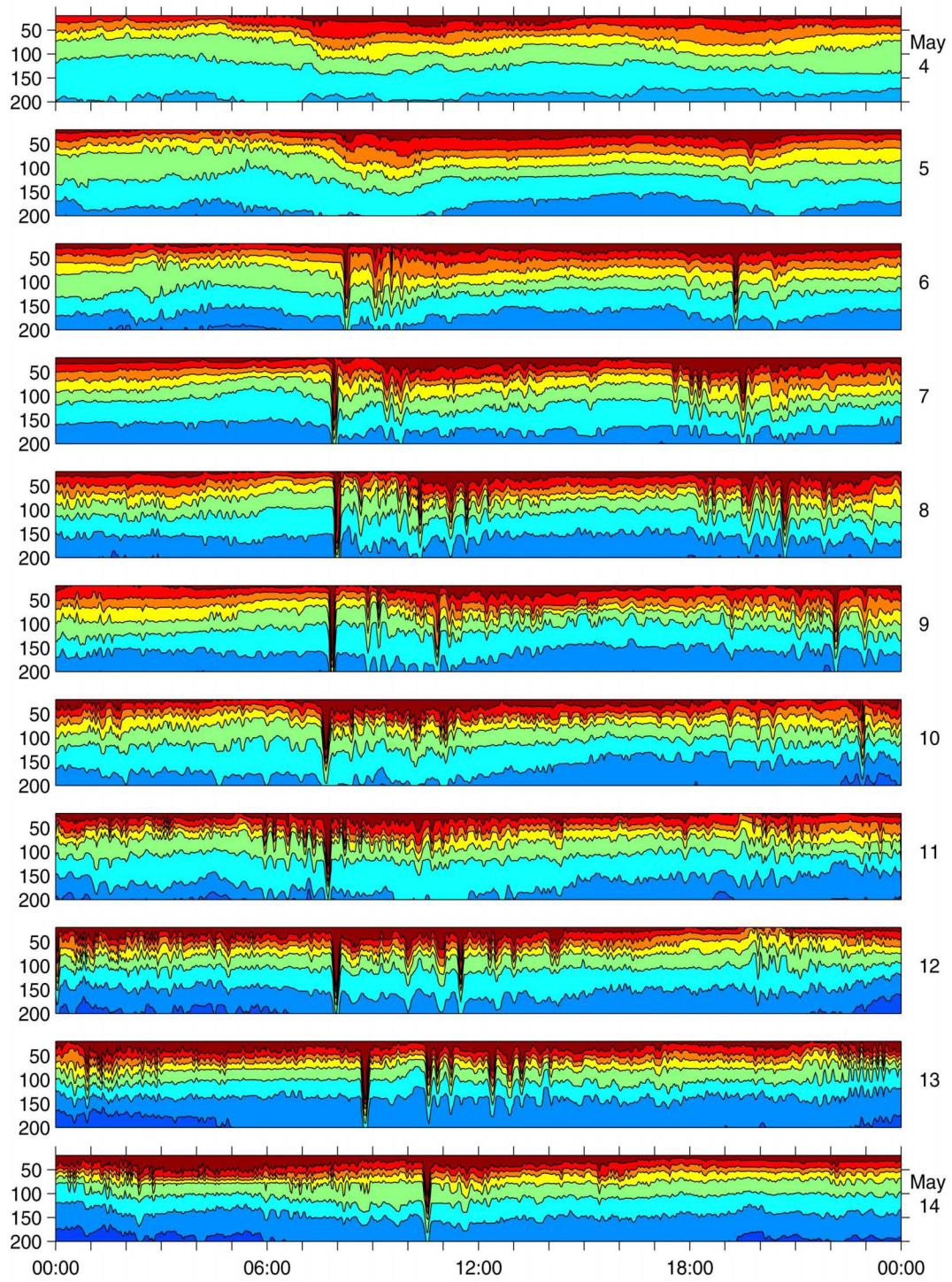


Figure 1. Stack plot of temperature at mooring S7 on the 350 m isobath. The bottom 150 m are not shown to allow a clearer presentation of the internal wave structure. All available temperature sensors were used to construct the plot. Each panel is one day (May 4 – 14, 2001) from 0000 to 2400 hours.

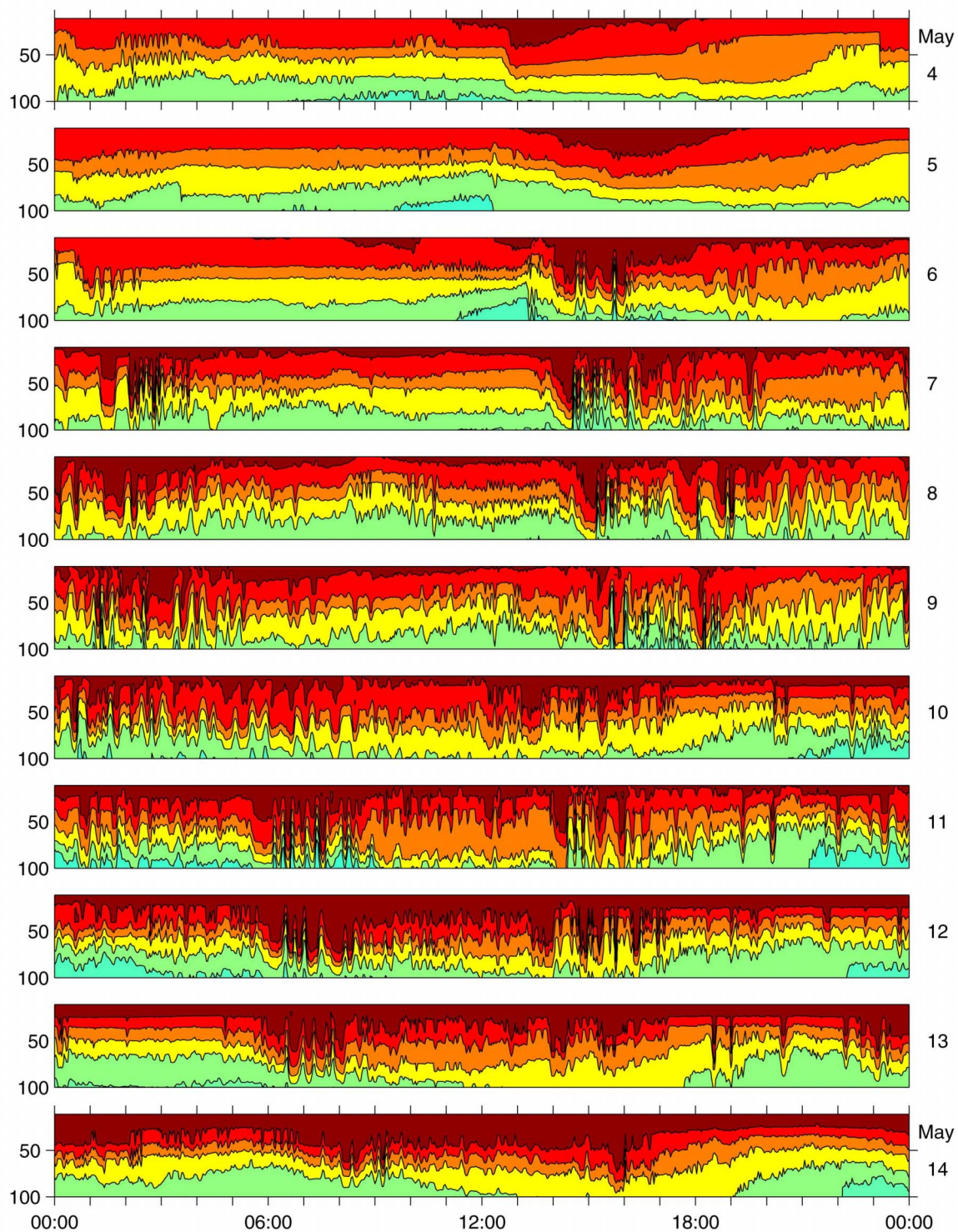


Figure 2. As in Figure 1 but for mooring S4 on the 120 m isobath. The top 100 m are shown. Note particularly packets of elevation waves near 1600 on 7 May and 0700 and 1500 on 11 and 12 May.

IMPACT/APPLICATION

The ASIAEX program is a follow-on to the New England Shelfbreak Primer experiment and as such will advance the state of the art in shallow water acoustic propagation prediction. The 2001 field program used more sophisticated acoustic sources and arrays, multiple towed vehicles, and alongshore as well as across-shore array configurations to better elucidate the subtle relationships between the water column variability, bottom and sub-bottom structure, and acoustic propagation loss. The ASIAEX analysis will lead to improved detection, location, identification, and targeting in the littoral zone. The large dramatic buoyancy changes induced by tidal bores and internal solitons have direct operational impacts on submarines in shallow water. The knowledge / predicatability of these features has found immediate use at PACSUBFLT.

TRANSITIONS

Profs. Ramp and Chiu visited Pearl Harbor to brief leadership, the boat COs, and sonar operators at PACSUBFLT on the ASIAEX results as they relate to acoustic operations and buoyancy control in the asian seas regions. The information provided has been incorporated into the pre-brief for embarking submarine leaders. Profs. Ramp and Chiu have been invited to make a second, follow-up trip to Pearl Harbor, perhaps accompanied by Adm. Roger Bacon, the new director of the NPS USW center who is assisting with the arrangements.

PUBLICATIONS

Ramp, S. R., J. Lynch, C. S. Chiu, P. Dahl, and J. Simmen, 2003: ASIAEX Fosters Advances in Shallow Water Acoustics. *EOS*, in press.

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